U.S. Army TRADOC Analysis Center
Naval Postgraduate School
Monterey, CA 93943

TRAC-MONTEREY

RESEARCH PLAN

of the

U.S. ARMY TRADOC ANALYSIS CENTER (TRAC) - MONTEREY

Center for
Advanced Simulation Concepts Research

for

FISCAL YEAR 1998

Lieutenant Colonel Michael L. McGinnis, Ph.D.
Director, TRAC-Monterey
Monterey, California

Mr. Michael F. Bauman, SES
Director, TRAC
Fort Leavenworth, Kansas

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I. TRAC-MONTEREY ADVANCED SIMULATION CONCEPTS RESEARCH CENTER

Purpose

TRAC-Monterey provides a small, full-time analytical capability to the U.S. Army Training and Doctrine Command (TRADOC) Analysis Center (TRAC). Key TRAC-Monterey functions include the following.

- Accomplish research in two major areas: (1) high-level computer simulations concepts and advanced technologies for modeling military operations focusing on system interoperability in distributed environments; and (2) practical, real-world military operations research problems of importance to the Army.

- Sustain a strong outreach program that maintains close ties between TRAC and various Army commands and agencies.

- Provide professional development opportunities for Army officers assigned to TRAC-Monterey from the FA49 community that enhance their skills, knowledge and experiences as both military officers and operations research analysts.

- Sponsor practical, academically and professionally enriching military oriented "experience tours," course projects and Masters Theses for officers from all branches of service attending the Naval Postgraduate School (NPS).

TRAC-Monterey's two major research thrusts, leading edge computer simulation research and current military operations research problems, ensure the Center remains relevant and closely linked with the Army.

World-class faculty and students from the Naval Postgraduate School (NPS) support the Center's research initiatives. TRAC-Monterey's research program offers NPS faculty a broad range of opportunities for studying meaningful, challenging applied problems that support NPS curricula and enhance professional development.

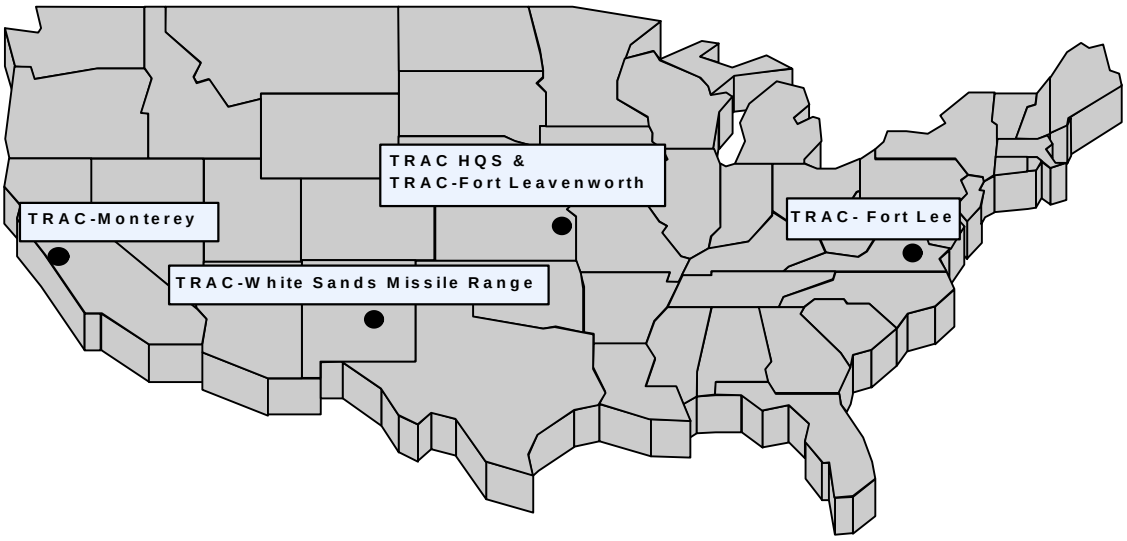
The Center's research program also supports students from all branches of military service with opportunities to investigate a wide range of interdisciplinary issues. TRAC's research program is particularly well suited to military officers who wish to apply many operations research, applied mathematics, engineering, and computer science concepts studied in the classroom to solving real-world military problems.

Organization and Facilities

TRADOC Analysis Center (TRAC) Headquarters is located at Fort Leavenworth, Kansas. TRAC-Monterey is one of four analysis centers organized under TRAC Heaquarters. The other centers shown in the figure below are TRAC-Fort Leavenworth, Kansas, TRAC-White Sands Missile Range, New Mexico, and TRAC-Fort Lee, Virginia.

TRAC-Monterey is located on the grounds of the Naval Postgraduate School, Monterey, California, and occupies office and laboratory space on the second and third floors of Building 203. Facilities on the 2d floor include offices for the director, analysts, administrative personnel, plus a conference room. There is a combat simulation laboratory, contractor work areas, and a second briefing area on the 3d floor.

Figure 1. U.S. Army TRADOC Analysis Centers (TRAC)



Personnel

The TRAC-Monterey Table of Distribution and Allowances (TDA) authorizes a director (O5), six military operations research analysts (O4/O3), and an administrative staff. An important step in developing military leaders of tomorrow is providing them with opportunities to develop their research and problem-solving skills while working on problems of importance to the Army. As mentioned above, TRAC-Monterey accomplishes this through a comprehensive research program that also maintains the Center's ties to the Army.

The full-time TRAC-Monterey analysts responsible for accomplishing the *Annual Research Plan for Fiscal Year 1998* are identified below.

Table 1. TRAC-Monterey Research Council

ORGANIZATION	NAME	PHONE	EMAIL
Director, TRAC	Mr. Michael F. Bauman, SES	688-5132	baumanm@trac.army.mil
Director, TRAC-Mtry	LTC Michael L. McGinnis, Ph.D	878-3088	mcginnim@ mtry.trac.nps.navy.mil
Analyst	MAJ Leroy A. Jackson, M.Sc.	878-4061	jacksonl@mtry.trac.nps.navy.mil
Analyst	MAJ William Murphy, Jr., M.Sc.	878-4056	murphyw@ mtry.trac.nps.navy.mil
Analyst	MAJ Gerald M. Pearman, M.Sc.	878-4062	pearmang@ mtry.trac.nps.navy.mil
Analyst	CPT Jeffery L. Huisingh, M.Sc.	878-4060	huisingj@mtry.trac.nps.navy.mil
Analyst	SFC Cary C. Augustine	878-4059	augustic@mtry.trac.nps.navy.mil

TRAC-Monterey credentials, summarized below in Table 2, include academic achievement, professional awards and education.

CIVILIAN EDUCATION	AWARDS & RECOGNITION
Ph.D. Sustems Engineering, Arizona Operations Research (*abd*), NPS Masters Operations Research & Statistics, RPI Applied Math, RPI Applied Math, CO School of Mines (2) Operations Research, NPS (2)	David Rist Prize, MORS Wilber Payne Award, AORS Distinguished Graduate, NPS Distinguished Graduate, NWC
PROFESSOR AND INSTRUCTOR DUTY	**ARMY BRANCHES**
Systems Engineering, USMA (2) National Security Decision Making, NWC	Aviation (2) Engineers Field Artillery (2) Infantry

TRAC-Monterey augments its research capability through several sources. A major source of support comes from NPS faculty who conduct TRAC sponsored research. A second source is NPS Masters students who work on TRAC-sponsored projects and who are advised by NPS faculty. Finally, private contractors provide software development, programming support, and also help with proof of principle demonstrations.

II. RESEARCH PROGRAM

Purpose of the Research Plan

The *Annual Research Plan* formalizes TRAC-Monterey's research and problem-solving activities for the upcoming fiscal year. The Plan provides a concise summary of each applied research or problem-solving project undertaken by TRAC-Monterey. The summaries include the client organization and point of contact, problem statement, proposal of work, project requirements and deliverables, estimates of milestones and man-years to complete the work, and TRAC analysts undertaking the work (see Sections III, IV and V). Section V gives the information on potential unfunded proposals under consideration at the time the *Annual Research Plan* was published. Proposals listed in Section IV may or may not be accomplished depending upon funding and time available during the upcoming fiscal year.

As mentioned above, TRAC-Monterey provides Army agencies with dedicated, long-term, applied research specializing in computer simulation interoperability as well as the application of operations research and applied mathematical methods to solve real world problems. The *Annual Research Plan* also announces TRAC-Monterey's research activities to other TRAC Centers, NPS faculty and students, and various agencies throughout the Department of Defense.

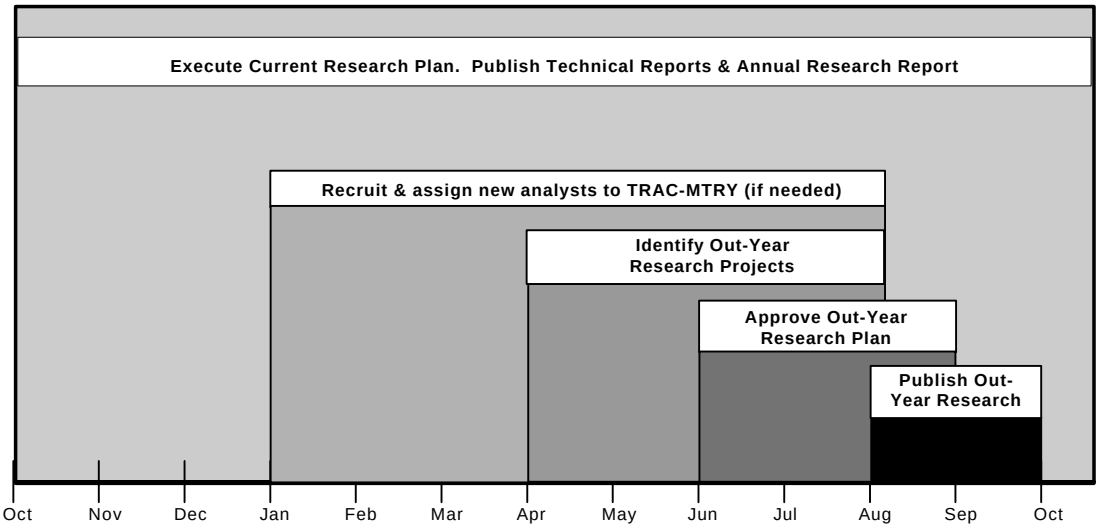
Annual Research Cycle

The Annual Research Cycle for TRAC-Monterey begins the first of October and continues through mid-October of the following year. The major phases of the research cycle are illustrated in Figure 2 below. The bands depict time periods for accomplishing major tasks in each phase of the annual research cycle (see text boxes running across each shaded band).

The research cycle begins with identification of potential research projects for the upcoming fiscal year. Potential projects include new and on-going projects (i.e., those carried forward from the current year). During this phase, TRAC-Monterey analysts prepare research proposals for each potential project (see Sections III, IV and V below).

In the second phase, the TRAC-Monterey Research Council (see Table 1 above) reviews each project proposal. The Council assesses the potential value of each project to the Army, its contribution to TRAC-Monterey's major research thrusts, ability and interest of TRAC-Monterey analysts to conduct the study, level of effort required, and project funding. In balancing these issues, TRAC-Monterey may occassionally execute unfunded projects that have a high payoff for the Army, TRAC, and the analyst accomplishing the research. All research projects approved for the upcoming fiscal year, plus other high-potenial (unfunded) proposals, are included in the Center's *Annual Research Plan* published in the 4th quarter of the fiscal year.

Figure 2. TRAC-Monterey Research Cycle



The final phase involves execution of the research plan. A Technical Report is produced for each research project undertaken that documents work performed by TRAC-Monterey. Finally, the Center also publishes an *Annual Research Report* summarizing research accomplished by TRAC-Monterey during the previous year, notable briefings and presentations. Each phase of the research cycle is sequenced with both the selection of incoming TRAC-Monterey analysts and the academic year of the Naval Postgraduate School.

III. ADVANCED SIMULATION RESEARCH FOR FY98

JLINK ASSESSMENT: COMPARATIVE ANALYSIS OF JANUS AND JLINK

PROJECT FY98-01

CLIENT ORGANIZATION

Headquarters, U.S. Army TRADOC Analysis Center (TRAC), ATTN: ATRC, Fort Leavenworth, KS 66027. Point of Contact: Mr. Michael F. Bauman, SES, Director, TRAC. DSN: 552-5132. *baumanm@trac.army.mil*

PROBLEM STATEMENT

Fielded in 1978, Janus was originally designed to operate in a stand-alone mode. However, the recent development of *World Modeler* by TRAC-Monterey makes it now possible for Janus to operate in a distributed mode with Janus systems, other constructive simulations, and virtual simulators. Verification and validation (V&V) of distributed Janus linked through World Modeler, referred to as *JLink*, is an important area of on-going research. TRAC-Monterey is currently investigating how consistently and accurately JLink reproduces stand-alone Janus data by comparing stand-alone and distributed Janus.

TRAC-Monterey recently compared data from three simulated military operations in two geographical environments (see Pearman, 1997). The scenarios involved U.S. and Warsaw Pact armored units, armored coalition forces, and U.S. infantry units operating at Fort Hunter-Liggett (HL), California, and in Southwest Asia (SWA). Stand-alone and distributed Janus data were compared using four performance measures: Family of Scatterable of Mines (FASCAM) kills, chemical kills, detection ranges, kill ranges, and force loss exchange ratios. Statistical analysis indicated JLink consistently detected and killed simulation entities at greater ranges than stand-alone Janus. In addition, stand-alone Janus artillery chemical munitions appeared more effective than JLink. Differences in effects between the two systems may be that stand-alone Janus aggregates artillery volleys and models them as a single impact whereas JLink models artillery volleys as individual rounds.

PROPOSAL OF WORK

Correct the artillery submodel problems in JLink relating to target detection ranges, kill ranges, and chemical kills. This will require modifications to JLink, re-running the scenarios, and conducting statistical analyses of the data. Determine what further adjustments are needed, if any, to minimize the differences between JLink and stand-alone Janus.

REQUIREMENTS AND MILESTONES

- JLink software modifications (JUL 97).
- Re-run Janus scenarios (AUG 97).
- Conduct statistical analysis (SEP 97).
- Report conclusions and recommendations (OCT 97).

DELIVERABLES

- Enhanced Executable.
- Technical Report.
- Recommendations for future studies.

ESTIMATED MAN YEARS

Requirement	Lead Investigator	Co-Investigator	Programmer
Modifications to World Modeler			1/10
Run scenarios and collect data	1/10		
Conduct analysis and write Technical Report	1/4	1/10	

LEAD INVESTIGATOR

MAJ Gerald M. Pearman, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-4062 (DSN 878). *pearmang@mtry.trac.nps.navy.mil*

CO-INVESTIGATOR

SFC Cary C. Augustine, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-4059 (DSN 878). *augustic@mtry.trac.nps.navy.mil*

CONTRACTOR

Rolands & Associates (R&A), Mr. William Caldwell, 500 Sloat Avenue, Monterey, CA 93940. (408) 373-2841.

REFERENCES

Pate, M. and Roussos, G., "JLink - A Distributed Interactive Janus," Winter 1996 Simulation Interoperability Workshop (SIW), Orlando, FL.

Pearman, G.M., "Comparison Study of Janus and JLink," Naval Postgraduate School Masters Thesis, Monterey, CA, June 1997.

JLINK SUPPORT: MANNED/UNMANNED RECONNAISSANCE SYSTEM CONCEPT EVALUATION PROGRAM (CEP)

PROJECT FY98-02

CLIENT ORGANIZATION

Air Maneuver Battle Lab (AMBL): ATZQ-CDB, Bldg. 5000, Fort Rucker, Alabama 36362. Point of Contact: CPT Steve Yost, Air Maneuver Battle Lab (AMBL). DSN: 558-9549. *stephen_yost_at_rucker-ms23a@rucker-emh4.army.mil*

PROBLEM STATEMENT

Aviation Branch at Fort Rucker, Alabama, does not currently use Janus entities as computer generated forces (CGF) during distributed exercises involving constructive simulations or virtual simulators. The Laboratory hopes to expand its analytical capability by connecting Janus to the Advanced Tactical Model (ATCOM) and the Extended Air Defense Simulation (EADSIM). The federated models will then be used to investigate potential benefits to situational awareness from mixing manned and unmanned reconnaissance systems on the battlefield.

A Distributed Interactive Simulation (DIS) compliant software system developed by TRAC-Monterey called *World Modeler* will provide connectivity between Janus and the two systems cited above. The combination of Janus and World Modeler, referred to as *JLink*, has demonstrated Janus interoperability with other constructive simulations and simulators including BDS-D, SIMNET, F-16 Synthetic Flight Training System, Virtual UAV, JSTARS Simulator, Close Combat Anti-Armor Weapon System Emulator, Tactical Artillery Fire Support Model (TAFSM), and ModSAF.

PROPOSAL OF WORK

Provide the Air Maneuver Battle Lab with DIS connectivity between Janus, ATCOM, and EADSIM using World Modeler.

REQUIREMENTS AND MILESTONES

AUG 97:	(1) Determine information transfer requirements between JLink and ATCOM/EADSIM. (2) Verify the correct enumeration of DIS PDUs and identify non-standard PDUs. (3) Obtain the ATCOM and EADSIM models from Fort Rucker.
SEP 97:	(1) Obtain terrain and entity data files from AMBL and TRAC-Fort Leavenworth, respectively. (2) Test JLink at TRAC-Monterey using ATCOM and EADSIM.
OCT-DEC 97:	(1) Conduct JLink proof-of-principle demonstration (POP-D) at Fort Rucker using ATCOM and EADSIM to support the Air Maneuver Battle Lab's evaluation of manned and unmanned reconnaissance systems. (2) Provide on-site support to AMBL at Fort Rucker during the POP-D.

DELIVERABLES

- Executable JLink compatible with Janus Version 6.3.
- Technical Report.

ESTIMATED MAN YEARS

Requirement	Lead Investigator	Co-Investigator	Programmer
Determine information transfer requirements	1/10		
Make JLink modifications	1/10		
Conduct JLink POP-D at Fort Rucker	1/10	1/16	

LEAD INVESTIGATOR

CPT Jeffrey L. Huisingh, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-4060 (DSN 878). *huisingj@mtry.trac.nps.navy.mil*

CO-INVESTIGATOR

SFC Cary C. Augustine, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-4059 (DSN 878). *augustic@mtry.trac.nps.navy.mil*

LTC Mike McGinnis, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-3086 (DSN 878). *mcginnism@mtry.trac.nps.navy.mil*

CONSTRACTOR

Rolands & Associates (R&A), Mr. William Caldwell, 500 Sloat Avenue, Monterey, CA 93940. (408) 373-2841.

REFERENCES

Pate, M.C., W.J. Caldwell and D.J. Ward, "Janus Fast Movers," US Army TRADOC Analysis Center-Monterey Technical Report No. R93WJ, August 1995.

Roussos, G.G. and M.C. Pate, "Janus Linkages to DIS (JLink)," US Army TRADOC Analysis Center-Monterey Technical Report No. NPS-TA-96001, October 1996.

Pearman, G.M., "Comparison Study of Janus and JLink," Naval Postgraduate School Masters Thesis, Monterey, CA, June 1997.

JLINK SUPPORT: VIRTUAL TERRAIN IMAGERY CONCEPT EVALUATION PROGRAM (CEP)

PROJECT FY98-03

CLIENT ORGANIZATION

Mounted Warfare Test Bed (MWTB), Mounted Maneuver Battlespace Lab, Attn: ATZK-MWT, Bldg 2021, Fort Knox, Kentucky 40121-5000. Point of Contact: Dr. Ken Hunt, Technical Oversight Representative, MWTB. (502) 942-1092. *huntk@ftknox-mwtbemh1.army.mil*

PROBLEM STATEMENT

In recent years, Janus has supported various Distributed Integrated Simulation (DIS) training exercises involving low fidelity virtual devices such as SIMNET. Janus *World Modeler*, a DIS compliant computer software system developed by TRAC-Monterey, links Janus to other constructive and virtual systems in distributed environments. This configuration, referred to as *JLink*, has successfully confederated Janus with several constructive simulations and virtual simulators (see Project FY98-02). However, Janus has not yet been linked with high fidelity devices such as the M1A2 DIS Simulator for analysis in a DIS environment.

PROPOSAL OF WORK

The Mounted Warfare Test Bed (MWTB) and TRAC-Monterey propose to jointly investigate the effects of different terrain representations in both constructive and virtual environments on the judgment and decision making of tactical commanders. Subjects will view synthetic terrain populated with Janus generated forces through two M1A2 DIS Simulators. The study will determine what effect, if any, different terrain representations have on military command and control and decision making. Investigators will attempt to measure and quantify differences, if they exist, using a standardized scenario presented in both constructive and virtual environments. This project proposes to use World Modeler for the first time to support an analytical study.

REQUIREMENTS AND MILESTONES

SEP 1997:	(1) Attend CEP coordination meeting at Fort Knox. (2) Convert JLink to Janus Version 6.88. (3) Determine information transfer requirements between JLink and the M1A2 DIS Simulator. (4) Identify non-standard PDUs. (5) Obtain entity database and S1000 terrain data from MWTB. (6) Convert S1000 terrain data to a Janus terrain database. (7) Test the federated system at TRAC-Monterey.
OCT 1997:	Ship JLink to MWTB.
FY98:	Conduct JLink POP-D at Fort Knox, Kentucky.

DELIVERABLES

- Executable JLink compatible with Janus Version 6.88.
- Janus terrain data files converted from S1000 data files provided by Fort Knox.
- Technical Report.

ESTIMATED MAN YEARS

Requirement	Lead Investigator	Co-Investigator	Programmer
JLink Conversion	1/10		1/10
Obtain and convert entity and terrain data files.	1/10		1/10
Test confederated system at TRAC-Monterey JLink/M1A2 DIS Simulator POP-D	1/10	1/10	1/10

LEAD INVESTIGATOR

CPT Jeffrey L. Huisingh, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-4060 (DSN 878). *huisingj@mtry.trac.nps.navy.mil*

CO-INVESTIGATOR

SFC Cary C. Augustine, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-4059 (DSN 878). *augustic@mtry.trac.nps.navy.mil*

LTC Mike McGinnis, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-3086 (DSN 878). *mcginnism@mtry.trac.nps.navy.mil*

CONSTRACTOR

Rolands & Associates (R&A), Mr. William Caldwell, 500 Sloat Avenue, Monterey, CA 93940. (408) 373-2841.

REFERENCES

Pate, M.C., W.J. Caldwell and D.J. Ward, "Janus Fast Movers," US Army TRADOC Analysis Center-Monterey Technical Report No. R93WJ, August 1995.

Roussos, G.G. and M.C. Pate, "Janus Linkages to DIS (JLINK)," US Army TRADOC Analysis Center-Monterey Technical Report No. NPS-TA-96001, October 1996.

Pearman, G.M., "Comparison Study of Janus and JLink," Naval Postgraduate School Masters Thesis, Monterey, CA, June 1997.

JLINK SUPPORT: CLOSE COMBAT ANTI-ARMOR WEAPON SYSTEM-CONCEPT EMULATOR (CCAWS-CE) PROOF-OF-PRINCIPLE DEMONSTRATION (POP-D)

PROJECT FY98-04

CLIENT ORGANIZATION

Program Manager (PM), Close Combat Anti-Armor Weapon System (CCAWS), PEO Tactical Missiles, Redstone Arsenal, Alabama 35898. Point of Contact: LTC Damian Bianca, Program Manager (PM): Follow On To Tow (FOTT). DSN: 746-4700. *bianca@ccaws.redstone.army.mil*

PROBLEM STATEMENT

In March 1997, TRAC-Monterey and PM CCAWS agreed to use Janus in a Distributed Interactive Simulation (DIS) proof-of-principle demonstration (POP-D) of the Close Combat Anti-Armor Weapon System-Concept Emulator (CCAWS-CE). Janus computer generated forces (CGF) will populate the synthetic battlefield during the CCAWS-CE POP-D using *World Modeler*: A DIS compliant software system developed by TRAC-Monterey. Software modifications to World Modeler were completed in May 1997. Trac-Mtry successfully demonstrated connectivity between Janus and the CCAWS-CE shortly thereafter in preparation for the upcoming CCAWS-CE POP-D at Fort Benning.

PROPOSAL OF WORK

Provide on-going DIS connectivity through World Modeler for the September 1997 CCAWS Technical Working Investigation Group (TWIG) demonstration in Huntsville, Alabama, and the CCAWS CE POP-D for the Commanding General (CG), U.S. Army Infantry Center, Fort Benning, Georgia in October 1997.

REQUIREMENTS AND MILESTONES

- TWIG, Huntsville, Alabama (SEP 97).
- POP-D for the CG, USAIC, Fort Benning, Georgia (OCT 97).

DELIVERABLES

- Support JLink/CCAWS Emulator TWIG and POP-D at Huntsville and Fort Benning, respectively.
- Technical Report.

ESTIMATED MAN YEARS

Requirement	Lead Investigator	Co-Investigator	Programmer
JLink modifications and testing			1/10
CCAWS TWIG (Huntsville) and POP-D (Fort Benning)	1/8		
Technical Report	1/8	1/16	

LEAD INVESTIGATOR

CPT Jeffrey L. Huisingh, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-4060 (DSN 878). *huisingj@mtry.trac.nps.navy.mil*

CO-INVESTIGATOR

SFC Cary C. Augustine, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-4059 (DSN 878). *augustic@mtry.trac.nps.navy.mil*

LTC Mike McGinnis, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-3086 (DSN 878). *mcginnism@mtry.trac.nps.navy.mil*

CONTRACTOR

Rolands & Associates (R&A), Mr. William Caldwell, 500 Sloat Avenue, Monterey, CA 93940. (408) 373-2841.

REFERENCES: None

STANDARD ARMY MODELING AND SIMULATION OBJECTS (SAMSO) STUDY

PROJECT FY98-05

CLIENT ORGANIZATION

US Army Modeling and Simulation Office (AMSO), 1111 Jefferson Davis Highway, Crystal Gateway North, Suite 503 (East), Arlington, VA 22202. Point of Contact: Ms. Lana McGlynn. (703) 601-0012, ext. 26 (DSN 329). *mcglyla@dcsopspo3.army.mil*

PROBLEM STATEMENT

The Deputy Undersecretary of the Army for Operations Research (DUSA-OR), Mr. Walt Hollis, directed the Army Modeling and Simulation Office (AMSO) study the problem of object management and draft a policy for object model development.

Object models are an important feature of the Department of Defense (DoD) High Level Architecture (HLA) and the Defense Modeling and Simulation Office (DMSO) Conceptual Model of the Mission Space (CMMS). Currently, all major DoD simulations under development use object-oriented methodologies. The major benefits of object-oriented programming include software reuse, ease of maintainability, interoperability, and rapid prototyping. First, however, a set of standard objects is needed to establish consistency among future Army models and simulations.

PROPOSAL OF WORK

Support AMSO's object model policy development by reviewing simulations and identifying "good" objects to serve as standards. Propose standard object class hierarchies. Finally, draft guidelines for creating and managing standard Army objects.

Important issues addressed by this research proposal include the following: What is the appropriate resolution for standard Army object classes? What are examples of appropriate standards for platform and unit level simulations? How are platform and unit level classes related? What are the guidelines for using standard objects? How are standard object attributes related to standard data? How are standard object behaviors related to standard algorithms? Are there additional standard algorithm or data requirements for standard objects? Are there opportunities to define standard interfaces for behaviors?

REQUIREMENTS AND MILESTONES

- Literature Review and preliminary work (APR-MAY 97).
- Problem definition (APR 97).
- Preliminary model investigation (MAY 97).
- Draft standard objects and class hierarchies (JUN 97).
- Document standard objects (JUL 97).
- Draft guidelines for using standard objects (SEP 97).
- Write Technical Report (FEB 98).

DELIVERABLES

- Examples of standard objects and standard object class hierarchies.
- A method to cross reference object attributes and standard data.
- A method to cross reference object behaviors and standard algorithms.
- Recommendations for development of additional standard data and algorithms.

- Guidelines and procedures for creating and using standard objects.
- Technical Report.

ESTIMATED MAN YEARS

Requirement	Lead Investigator	Co-Investigator	Programmer
Literature Review and Preliminary Work	1/8		
Draft Standard Army Object Model Policy	1/4		
Technical Report	1/8	1/16	

LEAD INVESTIGATOR

MAJ Leroy A. Jackson, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-4061 (DSN 878). *jacksonl@mtry.trac.nps.navy.mil*

CO-INVESTIGATOR

Professor Arnold Buss, Department of Operations Research, Naval Postgraduate School Monterey, CA 93943. (408) 656-3259. *bussa@or.nps.navy.mil*

CONTRACTOR: None

REFERENCES: None

JANUS SIMULATION OBJECT MODEL (JSOM)

PROJECT FY98-06

CLIENT ORGANIZATION

Headquarters, U.S. Army TRADOC Analysis Center (TRAC), ATTN: ATRC, Fort Leavenworth, KS 66027. Point of Contact: Mr. Michael F. Bauman, SES, Director, TRAC. DSN: 552-5132. *baumanm@trac.army.mil*

PROBLEM STATEMENT

Janus, developed by TRAC in 1978, is a closed, interactive, six-sided, high resolution, stochastic simulation used throughout the Army for both analysis and training. TRAC has made a significant investment in Janus through numerous revisions and enhancements. In 1996, the Department of Defense directed that all simulations must comply with High Level Architecture (HLA) standard by FY2001. Given this mandate, TRAC-Monterey initiated a study to investigate the feasibility of including Janus in future HLA federations. Preliminary findings suggest creating an object model of a legacy simulation coded in a procedural language, such as Janus, to make it HLA compliant is a feasible but challenging task.

PROPOSAL OF WORK

This on-going research will continue development of a Janus Simulation Object Model (JSOM) as a step towards development of a HLA compliant Janus. The research will provide a general methodology for creating an object model from a legacy simulation. Specifically produce an object representation of Janus documented in the HLA Object Model Template (OMT) format. The JSOM OMT will be documented using the *Aegis Research Object Model Development Tool*.

REQUIREMENTS AND MILESTONES

- Identify Janus objects, attributes, and interactions (JAN 1997).
- Create Janus object class hierarchies (FEB 97).
- Develop a Janus Simulation Object Model (SOM) (MAR 97).
- Derive a methodology for creating SOMs for legacy simulations (MAY 97).
- Propose topics for future research in SOM development (JUN 97).
- Produce a technical report (NOV 97).

DELIVERABLES

- Janus Simulation Object Model (JSOM).
- Janus class hierarchies.
- Methodology for developing HLA SOMs for legacy simulations.
- Technical Report.

ESTIMATED MAN YEARS

Requirement	Lead Investigator	Co-Investigator	Programmer
JSOM Development	1/4	1/4	
Technical Report	1/8	1/16	

LEAD INVESTIGATOR

MAJ Leroy A. Jackson, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-4061 (DSN 878). *jacksonl@mtry.trac.nps.navy.mil*

CO-INVESTIGATOR

Professor Arnold Buss, Department of Operations Research, Naval Postgraduate School, Monterey, CA 93943. (408) 656-3259. *bussa@or.nps.navy.mil*

CONTRACTOR: None

REFERENCES

Defense Modeling and Simulation Office, "HLA Rules, 1.0," August 1996.

Defense Modeling and Simulation Office, "HLA Object Model Template, 1.0," August 1996.

Bean, T., "Advanced Distributed Simulations for Analysis (ADSA '96) Workshop," PHALANX, Vol. 29, No. 3, September 1996.

Defense Modeling and Simulation Office, "HLA Federation Development and Execution Process (FEDEP) Model, 1.0," August 1996.

HLA FEDERATE FOR DATA COLLECTION AND ANALYSIS

PROJECT FY98-07

CLIENT ORGANIZATION

Headquarters, U.S. Army TRADOC Analysis Center (TRAC), ATTN: ATRC, Fort Leavenworth, KS 66027. Point of Contact: Mr. Michael F. Bauman, SES, Director, TRAC. DSN: 552-5132. *baumanm@trac.army.mil*

PROBLEM STATEMENT

The quality of studies, tests, experiments and after action reviews (AARs) depends in large measure on accurate, timely, and relevant data. This is true in all simulation domains: Advanced Concepts and Requirements (ACR), Research Development and Acquisition (RDA), and Training, Exercises and Military Operations (TEMO).

Conventional, closed simulations generally feature built-in capabilities for data logging and post processing. Data collection in Distributed Interactive Simulations (DIS) is usually accomplished through top-down data logging procedures. Unfortunately, this often generates overwhelming amounts of data that may not be relevant to the study. In addition, data overload makes reconstructing and analyzing DIS events from locally logged simulation data a tedious, time consuming task.

As advanced modeling and simulation (M&S) technologies now under development, such as High Level Architecture (HLA), gain acceptance in the ACR, RDA, and TEMO domains, new methods for collecting and analyzing data will be needed. However, no approaches for data collection and analysis in a HLA environment have yet been developed and accepted by the M&S community. This is due to the unique challenges of collecting and analyzing data in HLA. For example, subscription to objects, attributes, and interactions must be specified ahead of time to avoid logging all network traffic. Additionally, real-time data processing (RTDP) procedures are needed for man-in-the-loop training simulation sessions where immediate feedback helps improve the effectiveness of learning and training.

PROPOSAL OF WORK

TRAC-Monterey proposes to design and prototype a general purpose analysis tool, called an Analysis Federate, for collecting and analyzing requisite, relevant data in a HLA environment. The Analysis Federate prototype will comply with industry specifications, standards, and protocols for HLA federates and will employ the Run-Time Infrastructure (RTI). The Analysis Federate will require specifying data requirements, performances measures and other derived data ahead of time to substantially reduce data logging requirements. This is a significant difference from data collection in DIS where all data must be collected and stored for later use. With the Analysis Federate, data subscription collects data tol be correlated and processed in real time, thereby substantially reducing the amount of data collected.

Other key features of the Analysis Federate include dynamic data storage and exchange, and reconfigurable graphic user interfaces (GUI) for archiving, processing, and presenting data. This will require development of a HLA RTI compatible GUI that enables system users to specify data requirements for an exercise, identify data to be collected in HLA using subscription and logging, and identify essential data analysis requirements during and after federated simulation execution. Development of the Analysis Federate prototype GUI will be accomplished at no cost to the government using previously developed government software.

REQUIREMENTS AND MILESTONES

Phase 1. HLA Federate Analysis System Design.

- Perform Object Oriented Analysis of the Analysis Federate prototype (JAN 98).
- Develop Simulation Object Model of the Analysis Federate prototype (MAR 98).

Phase 2. Analysis Federate Prototype Development.

- Identify and develop Analysis Federate objects (JUL 98).
- Implement HLA RTI for HLA Analysis Federate (NOV 98).
- Conduct distributed simulation experiments (DEC 98).

Phase 3. Develop prototype and document results.

- Document Analysis Federate services (MAR 99).
- Document data collection procedures (MAY 99).
- Write Technical Report (JUL 99).

DELIVERABLES

- HLA Analysis Federate prototype for data collection and analysis.
- Procedures for data collection in distributed simulation environments.
- Technical Report.

ESTIMATED MAN YEARS

Requirement	Lead Investigator	Co-Investigator	Programmer
Design Analysis Federate	1/2	1/8	
Develop Analysis Federate Prototype	1/2	1/12	
Test Analysis Federate	1/4		
Technical Report	1/8	1/12	

LEAD INVESTIGATOR

MAJ William S. Murphy Jr., TRAC-Monterey, P.O. Box 8692, Monterey, CA 93943. (408) 656-4056 (DSN 878). *murphyw@mtry.trac.nps.navy.mil*

CO-INVESTIGATOR

Professor Arnold Buss, Department of Operations Research, Naval Postgraduate School, Monterey, CA 93943. (408) 656-3259. *bussa@or.nps.navy.mil*

MAJ Leroy A. Jackson, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-4061 (DSN 878). *jacksonl@mtry.trac.nps.navy.mil*

LTC Mike McGinnis, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-3086 (DSN 878). *mcginnism@mtry.trac.nps.navy.mil*

CONTRACTOR

Rolands & Associates (R&A), Mr. William Caldwell, 500 Sloat Avenue, Monterey, CA 93940. (408) 373-2841.

REFERENCES

Jackson, L. and R. Wood, "Exploring the High Level Architecture for Analysis in an Advanced Distributed Simulation," 1997 Spring Simulation Interoperability Workshop (SIW) Working Paper # 122, Orlando, FL.

IV. MILITARY OPERATIONS RESEARCH FOR FY98

A GRAPH AND NETWORK COMPONENT FOR DYNAMIC PLANNING IN A LOOSELY COUPLED SYSTEM

PROJECT FY98-08

CLIENT ORGANIZATIONS

Air Force Office of Scientific Research, ATTN: Dr. Neal Glassman (Code NM), 110 Duncan Avenue, Suite 100, Bolling AFB, Washington D.C. 20332-0001. Point of Contact: Dr. Neal Glassman (Code NM). (202) 767-5026. *neal.glassman@afosr.af.mil*

Office of Naval Research, ATTN: Dr. Donald K. Wagner, Division of Mathematical Sciences Code 1111, 800 N. Quincy Street, Alexandria, VA 22217-5000. Point of Contact: Dr. Donald K. Wagner. (703) 696-4313. *wagnerd@onr.navy.mil*

PROBLEM STATEMENT

Military planning systems must evolve to meet the challenges of conducting military operations in the information age. The *Department of Defense Joint Vision 2010* and the *Air Force New World Vistas* suggest the next generation of military planning systems will accelerate the tempo of analysis, operate over computer networks and on different computer platforms, and incorporate simulation technology for mission planning. Even the best-integrated planning tools today do not provide adequate interoperability, platform independence, or extensibility. Future planning systems must address new situations and needs of decision-makers that designers have not yet anticipated. These planning systems will feature an open architecture enabling new functions and capabilities to be added without disruption.

Incorporating graph and network models, and associated algorithms, into a dynamic military planning system has great potential for overcoming the shortcomings noted above. Traditional uses of graph and network models include planning, optimization, and simulation. Graph and network models, implemented in a loosely coupled dynamic planning system through a set of Java interfaces may provide the flexibility and adaptability needed in military planning and decision-making systems of the future.

PROPOSAL OF WORK

Design and develop an extensible library of graph and network algorithms for military planning in dynamic, distributed systems. Implement selected graph and network algorithms as a component (i.e., module) of a loosely coupled dynamic planning system.

REQUIREMENTS AND MILESTONES

- Design Java interfaces and classes for graph and network algorithms in a loosely coupled dynamic planning system. This will include developing an extensible subset of classes and subclasses to support system functions. Generic programming concepts will be used to design interfaces so future algorithms may be easily incorporated into the loosely coupled system.
- Implement algorithms and classes to produce a graph and network component prototype.
- Conduct formal component prototype testing and integrate the component into the dynamic planning system.

DELIVERABLES

- Graph and network component object model developed using *Rational Rose Java*.
- Graph and network component prototype programmed in Java.
- Technical Report.
- Proof of principle demonstration (POP-D) of the dynamic planning system with the graph and network component.

ESTIMATED MAN YEARS

Requirement	Lead Investigator	Co-Investigator	Programmer
Object Oriented Analysis and Design	1/6	1/12	
Component implementation	1/6	1/12	
System integration and testing	1/12	1/6	

LEAD INIVESTIGATOR

MAJ Leroy A. Jackson, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-4061 (DSN 878). *jacksonl@mtry.trac.nps.navy.mil*

CO-INVESTIGATOR

Professor Gordon H. Bradley, Department of Operations Research, Naval Postgraduate School, Monterey, CA 93943. (408) 656-3259. *bradley@or.nps.navy.mil*

Professor Arnold Buss, Department of Operations Research, Naval Postgraduate School, Monterey, CA 93943. (408) 656-3259. *bussa@or.nps.navy.mil*

CONTRACTOR: None

REFERENCES

Army Vision 2010, Department of the Army, *http://160.147.68.21:80/2010/*

Bradley, G., "Dynamic and Interactive Electronic Research Publications Using Java," February 1996, Technical Report Online at *http://web.nps.navy.mil/~gbradley*

Bradley, G. and A. Buss, unpublished research report entitled "An Architecture for Dynamic Planning Using Loosely Coupled Components," July 1997.

Buss, A. and K. Stork, "Discrete-Event Simulation on the World Wide Web Using Java," Proceedings of the 1996 Winter Simulation Conference, December 1996.

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Jackson, L., "Graph Standard Project," online research proposal located at *http://www.trac.nps.navy.mil/~jacksonl/OA4910/project/project.html*, August 1996.

LAND WARRIOR TACTICS, TECHNIQUES, AND PROCEDURES (TTPs)

PROJECT FY98-09

CLIENT ORGANIZATION

TRADOC Systems Management Team (TSM) Soldier, Attn: ATZD–TS, Fort Benning, Georgia 31905-5405. Point of Contact: LTC Pat Berger, Director, TSM Soldier. DSN 835-7738. *bergerp@benning-emh-2.army.mil*

PROBLEM STATEMENT

The potential revolution in military affairs brought on by the infusion of new technologies, especially in the C4ISR domain, demands that new methods be developed to train infantry soldiers. Currently, there is a significant gap in training that must be bridged to take the infantry soldier into the 21st century. Future training opportunities will be conducted in both live and virtual environments. One new simulation for training infantry soldiers is *Soldier Station* under development by TRAC-White Sands Missile Range. However, this technology is not yet fielded. There is very little guidance currently available in the areas of tactics, techniques, or procedures (TTPs) for using these new training systems to enhance and sustain infantry training.

PROPOSAL OF WORK

Study new technologies developed for Land Warrior and develop techniques for training infantry soldiers. The study objectives are to: (1) recommend tactics, techniques, and procedures for training infantry soldiers using 21st century technology; (2) integrate Soldier Station or similar devices as a training tool for Land Warrior by incorporating Land Warrior's information technologies into the simulation; and (3) explore other virtual training devices for enhancing infantry training.

REQUIREMENTS AND MILESTONES

- Background research and literature review of Land Warrior and virtual simulations for Land Warrior (FEB 98).
- Develop tactics, techniques, and procedures for Land Warrior training (MAY 98).
- Write Technical Report (JUN 98).

DELIVERABLE

- Technical Report.
- Tactics, techniques, and procedures (TTPs) for Land Warrior training.

ESTIMATED MAN YEARS

Requirement	Lead Investigator	Co-Investigator	Programmer
Land Warrior familiarization	1/10		
Study existing and new modes of training	1/4		
Write Technical Report	1/10	1/10	

LEAD INVESTIGATOR

SFC Cary Augustine TRAC-Monterey, PO BOX 8692, Monterey, CA 93943. (408) 656-4059 (DSN 878). *augustic@mtry.trac.nps.navy.mil*

CO-INVESTIGATOR

CPT Jeffrey L. Huisingh TRAC-Monterey, PO BOX 8692, Monterey, CA 93943. (408)656-4060 (DSN 878) *huisingj@mtry.trac.nps.navy.mil*

LTC Michael McGinnis TRAC-Monterey, PO BOX 8692, Monterey, CA 93943. (408) 656-3788 (DSN 878). *mcginnism@mtry.trac.nps.navy.mil*

CONTRACTOR: None

REFERENCES: None

MAXIMIZING ARMY DENTAL READINESS THROUGH IMPROVED DENTAL FACILITY SCHEDULING

PROJECT FY98-10

CLIENT ORGANIZATION

Commander, US Army Dental Command, Fort Sam Houston, TX 78234-6004. Point of Contact: COL Frank Nasser, Chief, Dental Corps Restructuring Initiative. DSN: 471-6528.

PROBLEM STATEMENT

The Army maintains dental clinics on installations throughout the world. Patient care varies significantly from clinic to clinic due to differences in staffing levels, patient density and demographics, and facilities. The extent to which clinics meet the dental needs of soldiers determines the dental readiness of military units throughout the Army. Currently, Army dental clinics use rules of thumb learned through trial and error to schedule patients and resources. Anecdotal evidence suggests these methods are inefficient, often lead to either under or over scheduling of patients and facilities, and suboptimal dental readiness.

PROPOSAL OF WORK

Design, develop, and implement a patient and dental facility software scheduling system for improving dental readiness of Army units. The Presidio of Monterey (POM) Dental Clinic at the Defense Language Institute, Monterey, California, will serve as the case study for model and software system development and testing. The objective of the study will be to implement a patient and dental facility scheduling system that improves Army dental readiness. The system will enable dental clinic managers to assess the impact of future changes to dental facilities on dental readiness before they are implemented. The widespread applicability of this project for improving dental readiness throughout the Army makes it an important area of research.

REQUIREMENTS AND MILESTONES

- Literature review and background research (AUG-DEC 97).
- Collect patient and dental clinic data (OCT-DEC 97).
- Develop scheduling performance measures. Develop a forecasting and scheduling model of the problem (JAN 98).
- Implement the scheduling model in a software scheduling system (MAR 98).
- Test, verify, and validate (V&V) the model and software system (APR 98).
- Write Technical Report (MAY 98).

DELIVERABLES

- Army Dental Facility Scheduling Software System.
- Technical Report.

ESTIMATED MAN YEARS

Requirement	Lead Investigator	Co-Investigator	Programmer
Background research and literature review	1/8		
Data Collection	1/8		
Model development and software system V&V	1/8		
System implementation and testing	1/8	1/16	
Technical Report	1/8	1/10	

LEAD INVESTIGATOR

CPT Jeffrey L. Huisingh, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-4060 (DSN 878). *huisingj@mtry.trac.nps.navy.mil*

CO-INVESTIGATOR

LTC Mike McGinnis, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-3086 (DSN 878). *mcginnism@mtry.trac.nps.navy.mil*

CONTRACTOR: None

REFERENCES

Allen, P.O., D.W. Ballash and G. Kimball, "Simulation Provides Surprising Staffing and Operation Improvements at Family Practice Clinics," 1997 Health Information and Management Systems Society Proceedings 4, 211-227.

Carlson, R.C., J.C. Hersey and D.H. Kropp, "Use of Optimization and Simulation Models to Analyze outpatient Health Care Settings," Decision Sciences 10 (1979): 412-432.

Fetter, R.B. and J. D. Thompson, "The Simulation of Hospital Systems," Operations Research 13 (September-October 1965), 689-711.

Robinson, G.H., P. Wing and L.S. Davis, "Computer Simulation of Hospital Scheduling Systems," Health Services Research 3 (1968), 130-141.

MILITARY HOUSING SOFTWARE SCHEDULING SYSTEM FOR ASSIGNMENTS, MAINTENANCE AND RENOVATIONS

PROJECT FY98-11

CLIENT ORGANIZATION

Headquarters, Naval Postgraduate School (NPS), Monterey, CA 93943. Point of Contact: CAPT Mary Meyer, Commanding Officer, Naval Support Activity, (408) 656-2406. *meyer@nps.navy.mil*

Headquarters, Presidio of Monterey (POM), Monterey, CA 93943. Point of Contact: COL David Gross, Garrison Commander. (408) 242-6518. *grossd@pom-emh1.army.mil*

PROBLEM STATEMENT

The Naval Support Activity (NSA) at the Naval Postgraduate School (NPS) administers military housing at La Mesa Village near NPS and Army housing at both the Presidio of Monterey in Monterey, California, and the Presidio of Monterey Annex at old Fort Ord. Residents include service members from all branches of military service attending the Naval Postgraduate School and the Defense Language Institute (DLI) at the Presidio of Monterey as well as permanent party assigned to NPS and DLI. The large student population creates a high turnover of housing that backlogs housing maintenance and public works. In turn, this creates housing assignment delays for many incoming students requiring them to stay in costly temporary off-post housing in the Monterey area. Housing scheduling is further complicated by renovation projects and breakdowns in the flow of information between housing managers, housing maintenance, and NPS and DLI Headquarters regarding inbound and outgoing students.

PROPOSAL OF WORK

Design, develop, and implement a mathematical model and software system for scheduling military housing in the NPS and DLI communities. The system will schedule housing assignments, maintenance, and renovations with the objective of simultaneously minimizing temporary, off-post military housing costs and the displacement of military personnel and their families.

REQUIREMENTS AND MILESTONES

- Background research (SEP 97).
- Develop military housing scheduling model (NOV 97).
- Implement the model in scheduling software system (JAN 98).
- Full system development (Mar 98).
- Write Technical Report (APR 98).

DELIVERABLES

- Military Housing Scheduling Software System.
- Network architecture for system implementation.
- Technical Report.

ESTIMATED MAN YEARS

Requirement	Lead Investigator	Co-Investigator	Programmer
Background research and model formulation	1/6		
Software system development, implementation & testing	1/6	1/10	
Full system development and user training	1/12		1/12

LEAD INVESTIGATOR

CPT Gerald M. Pearman, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-4062 (DSN 878). *pearmang@mtry.trac.nps.navy.mil*

CO-INVESTIGATOR

LTC Mike McGinnis, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-3086 (DSN 878). *mcginnism@mtry.trac.nps.navy.mil*

Professor J.F. (Fritz) Raffensperger, Department of Operations Research, Naval Postgraduate School, Monterey, CA. (408) 656-3113. *jfraffen@wposmtp.nps.navy.mil*

CONTRACTOR: None

REFERENCES

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IV. UNFUNDED RESEARCH ACTIVITIES

ARMY HUMAN RESOURCES BATTLE LAB ENGINEERING AND DESIGN

PROJECT FY98-12

CLIENT ORGANIZATION

Headquarters, Department of the Army, Assistant Deputy Chief of Staff for Personnel (A/DCSPER), Pentagon, Washington, D.C. Point of Contact: MG David H. Ohle, A/DCSPER, (703) 695-2250 (DSN 225). *david.ohle@us.army.mil*

PROBLEM STATEMENT

Soldiers are the Army's most valuable and most perishable resource. Proper management of military manpower is critical to the continued health of the Army and security of the nation. Recruiting, training, educating, and professionally developing the forces needed for staffing a high technology Army will become more complex as we move into the 21st Century. This suggests the Army may need a new organization for modeling and analyzing budget, manpower, and readiness issues.

PROPOSAL OF WORK

Apply a systems engineering approach to designing an Army Human Resources Battle Lab for managing military manpower in the 21st Century.

REQUIREMENTS AND MILESTONES

- Literature review and background research (DEC 97).
- Collect data (OCT-DEC 97).
- Design Army Human Resources Lab (JUL 98)
- Write Technical Report (SEP 98).

DELIVERABLE: Technical Report.

ESTIMATED MAN YEARS

Requirement	Lead Investigator	Co-Investigator	Programmer
Background research and literature review	1/8		
System Design	1/4		
Write Technical Report	1/10		

LEAD INVESTIGATOR

LTC Mike McGinnis, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-3086 (DSN 878). *mcginnism@mtry.trac.nps.navy.mil*

CO-INVESTIGATOR: TBD

CONTRACTOR: TBD

REFERENCES: None

HIGH LEVEL ARCHITECTURE (HLA) COMPUTER GENERATED FORCES (CGF) FOR FORCE XXI

PROJECT FY98-13

CLIENT ORGANIZATION

Headquarters, U.S. Army TRADOC Analysis Center (TRAC), ATTN: ATRC, Fort Leavenworth, KS 66027. Point of Contact: Mr. Michael F. Bauman, SES, Director, TRAC. DSN: 552-5132. *baumanm@trac.army.mil*

PROBLEM STATEMENT

The U.S. Army TRADOC Analysis Center (TRAC), the Army's preeminent source of land warfare modeling and analysis, has sustained a strong investment in the development of constructive simulations for analysis and training spanning nearly two decades. This commitment has made TRAC the leader in land warfare simulations throughout the Department of Defense. Janus, arguably TRAC's most successful, high resolution, constructive, land warfare simulation is widely used throughout the Army and by other services and allied nations for both analysis and training.

In September 1996, a Department of Defense (DoD) directive from Under Secretary of Defense for Acquisition and Technology (USD(A&T)), Dr. Paul Kaminski, mandated that all computer simulations for military operations must meet High Level Architecture (HLA) standardization requirements by FY2001. Furthermore, any DoD simulation failing to comply with HLA standards shall be retired.

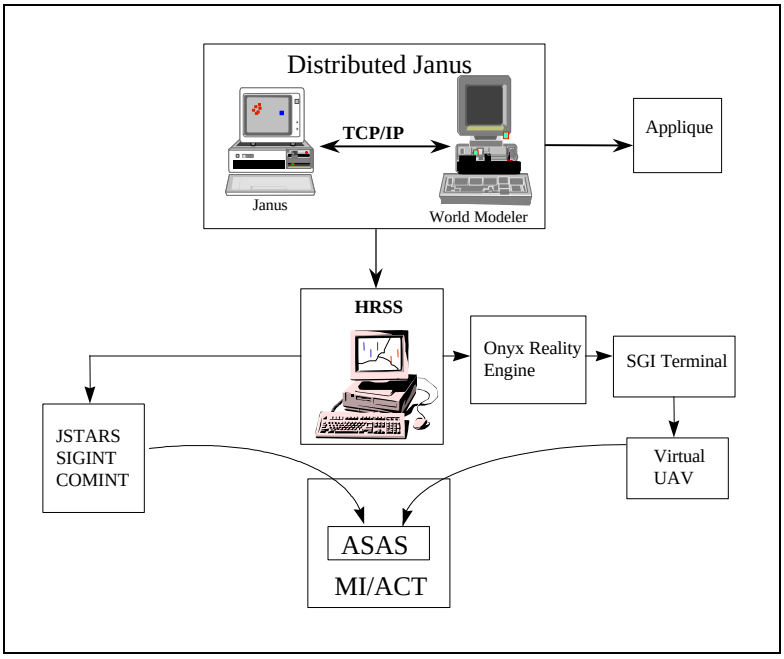
DoD's HLA mandate has major implications for both TRAC and Janus users. TRAC must either undertake development of a HLA compliant Janus or risk losing Janus users to new HLA compliant simulations that may be developed in the future. If TRAC chooses not to develop a HLA Janus, current Janus users will be confronted by the prospect of either replacing Janus with a new, expensive HLA compliant system that may not be available for years to come or losing existing analysis and training capability provided by Janus.

Benefits of Developing a HLA Compliant Janus to FORCE XXI

World Modeler, researched and developed by TRAC-Monterey, is a computer software program that links Janus in a Distributed Interactive Simulation (DIS) environment with other constructive and virtual simulation systems. The combination of World Modeler and Janus, referred to as *JLink*, proved highly beneficial in preparing brigade staff sections for the recently completed Task Force XXI Advanced Warfighting Experiment (AWE).

During the AWE, JLink populated the High Resolution Simulation Stimulator (HRSS) battlefield, in real time, with Janus Computer Generated Forces (CGF). These forces were used by military intelligence (MI) systems during Task Force XXI AWE preparation and execution. Intelligence systems used included the virtual Unmanned Aerial Vehicle (UAV) system, the Joint Surveillance, Targeting & Attack, Radar System (JSTARS). Information collected by the MI systems enabled the Military Intelligence Analysis & Control Team (MI/ACT) to process and disseminate intelligence via the All Source Analysis System (ASAS). This resulted in realistic training for the MI/ACT and Brigade intelligence staff section with Force XXI information technologies that provided automated situational awareness, targeting, and battle damage. The alternative to JLink was "scripted" scenarios; an option that would have significantly degraded the realism of the scenarios used during AWE preparation. The figure below shows connectivity between JLink and other systems during preparation for the Task Force XXI AWE.

JLink Support for Task Force XXI AWE



As shown above, HRSS received DIS protocol data units (PDUs) from JLink. The HRSS then disaggregated and arrayed military units populating the simulated Janus battlefield PDUs into lower -level platforms according to threat templates. Next, the system fed the PDUs through an Onyx Reality Engine and SGI terminal to create a virtual representation of the battlefield that could be viewed, for example, by a UAV operator. In other cases, military intelligence systems, such as JSTARS, received information directly from HRSS based on system user inputs. HRSS then automatically generated intelligence reports from the current Janus battlefield situation.

It is important to note *development of a HLA compliant HRSS is currently underway*. If the DoD directive mandating HLA compliance is adhered to, and HRSS and other systems become HLA compliant, then TRAC must undertake development of a HLA Janus or risk losing Janus customers. Major benefits of this research are highlighted below.

- A HLA compliant Janus, supported by World Modeler, will provide the Military Intelligence and Signal communities with a real-time, train-as-you-fight capability that current systems cannot match and future (proposed) systems may not meet for years to come.
- A HLA compliant JLink avoids the use of scripted military intelligence scenarios for simulated exercises, thereby enhancing the realism of the exercises for training and analysis. Scripted scenarios also makes it impractical to use automated analysis systems such as ASAS, thereby negating the value of training in a distributed simulation environment.
- Development of a HLA Janus will serve as a test bed for other HLA projects such as the Analysis Federate currently funded by SIMTECH and under development at TRAC-Monterey.
- Finally, development of a HLA Janus will enhance Janus interoperability with future HLA constructive and virtual simulations such as Soldier Station. This research will provide Army students at NPS with thesis topics that also benefit the Army. Soldier Station, a virtual simulator developed by TRAC-White Sands Missile Range (WSMR), is used to analyze soldier situational awareness.

PROPOSAL OF WORK

Develop and implement a HLA compliant Janus prototype to support future Force XXI AWEs and other force analysis experiments. This work will be accomplished in two phases. First, develop a Janus Simulation Object Model (JSOM) by identifying Janus object attributes and interactions necessary for federation interoperability. JSOM development will leverage previous TRAC-Monterey object model research. Once completed, JSOM specifies information HLA Janus publishes within the federation. Second, develop a methodology for implementing JSOMs in a HLA environment. This includes procedures that enable a Janus-to-RTI interface for message ordering and routing. This work will leverage Janus user interfaces, databases and JLink technology developed previously. The HLA Janus prototype will be tested in a Janus-to-Janus federation.

REQUIREMENTS AND MILESTONES

- Review JSOM research (SEP 97).
- Revise World Modeler to make it HLA compliant (OCT 97-MAR 98).
- Develop and test HLA Janus Prototype (MAR-SEP 98).
- Write Technical Report (DEC 98).

DELIVERABLES

- HLA compliant Janus.
- Technical Report.

ESTIMATED MAN YEARS

Requirement	Lead Investigator	Co-Investigator	Programmer
Review JSOM research	1/4		
Design, develop and test HLA Janus	1/2		
Write Technical Report	1/8	1/10	

LEAD INVESTIGATOR

CPT Gerald M. Pearman, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-4062 (DSN 878). *pearmang@mtry.trac.nps.navy.mil*

CO-INVESTIGATOR

MAJ Leroy A. Jackson, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-4061 (DSN 878). *jacksonl@mtry.trac.nps.navy.mil*

LTC Mike McGinnis, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-3086 (DSN 878). *mcginnism@mtry.trac.nps.navy.mil*

CONTRACTOR

Rolands & Associates (R&A), William Caldwell, 500 Sloat Avenue, Monterey, CA 93940. (408) 373-2841.

REFERENCES

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MODELING AND ANALYSIS SUPPORT FOR THE ARMY CHIEF OF STAFF (CSA) STAFF GROUP

PROJECT FY98-14

CLIENT ORGANIZATION

Headquarters, Department of the Army, CSA Staff Group, Pentagon, Washington, D.C. Point of Contact: COL Hugh F.T. Hoffman, Director, CSA Staff Group. (703) 693-8363 (DSN 223). *hoffmhf@hqda.army.mil*

PROBLEM STATEMENT

Modeling and analysis by Headquarters, Department of the Army (HQDA), range from resource scheduling to readiness to military personnel development. Time, budget, and manpower constraints make it difficult for HQDA staff elements to accomplish all modeling and analysis needed for some studies.

PROPOSAL OF WORK

Working through the CSA Staff Group, TRAC-Monterey will support Headquarters, Department of the Army, with modeling and analysis support as needed. Projects will involve officer attending the Naval Postgraduate School, and other institutions, with opportunities to apply analytical tools learned in the classroom to real-world problems of importance to the Army. Potential areas of analysis include military readiness, analysis of Force XXI experimental results, resource scheduling, budget analysis, force design and development, and military personnel modeling.

REQUIREMENTS AND MILESTONES: TBD

DELIVERABLE: Technical Report(s).

ESTIMATED MAN YEARS: TBD

LEAD INVESTIGATOR

LTC Mike McGinnis, TRAC-Monterey, PO Box 8692, Monterey, CA 93943. (408) 656-3086 (DSN 878). *mcginnism@mtry.trac.nps.navy.mil*

CO-INVESTIGATOR: TBD

CONTRACTOR: TBD

REFERENCES: None